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CONSTRUCTION AND EVALUATION OF FIRL HYBRID FILTERS FOR USE WITH APOLLO STANDARD INITIATOR

by

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THE FRANKLIN INSTITUTE RESEARCH LABORATORIES

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"Construction and Evaluation of
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Dr. J. R. Feldmeier
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ABSTRACT

Twelve FIRL filters of the Hybrid type were constructed; six each of a two pin and a four pin configuration, for use in conjunction with the Apollo Standard Initiator. Terminated power loss measurements were performed on each filter and the results plotted with respect to frequency in the range of 100 kHz to 1000 MHz.

Pictures and assembly drawings are included for both types of filters and a brief description of the method of manufacture is given.

Problems associated with potting compounds are discussed and various other electrical properties are presented in tabular form.

ACKNOWLEDGEMENTS

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Inquiries pertaining to the contract should be directed to the sponsoring agency or to the FIRL Laboratory Manager.

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I. INTRODUCTION

Under contract with the NASA Manned Spacecraft Center, Houston, Texas, Task Order No. NAS9-3787-3 the Franklin Institue Research Laboratories, (FIRL) has fabricated six each of two types of hybrid filters; namely a four pin or double bridgewire type and a two pin or single bridgewire type for use in conjunction with the Apollo Standard Initiator. These filters were to be constructed as per FIRL drawing No. B2303-B2 and B2303-B3, which were approved for manufacture by NASA personnel, and the attenuation capabilities of each filter were to be determined and presented in graphical form.

This report details the results of this program.

2. DESCRIPTION OF FILTERS

The FIRL filters are of the hybrid type; that is, they consist of a series combination of insulated ferrite beads and a ferrite inductor coil mounted in each leg of the filter. This combination of ferrites and coil represents a marriage of the attenuating properties of each component to obtain optimum results, in keeping with minimum size and weight, across a frequency band of 100 kHz to 1000 MHz.

The four pin type, a photograph of which is shown in Figure 2-1 consists of four ferrite and coil assemblies concentrically mounted in a brass grounding ring, with the input ends of the ferrite bead combination soldered to a solder mount receptable connector and the output ends of the inductor coil soldered to the pins of a straight plug. The four ferrite and coil assemblies are enclosed in brass tubes which after encapsulating the assembly with potting compound are soldered into both connectors, effectively completing the assembly. These details of construction are shown in Figure 2-2 which is a reduced copy of Drawing B2303-B2.

The two pin filter, a photograph of which is shown in Figure 2-3, is essentially made the same way. However, in order to reduce overall length and weight the ferrite assemblies are mounted at 90° to the axis of the filter in a brass housing so designed as to prevent RF from leaking from one lead to another and also to effectively ground the assemblies to the case. Figure 2-4 is a reduced copy of drawing B2303-B3. The connectors used for both types were of the Bendix pygmy type; number 8 body size.

The four pin filter weighs approximately 65 grams including the connectors and is $2\frac{11}{16}$ inches in overall length and $\frac{21}{32}$ inches in diameter. The two pin filter weighs approximately 44 grams and is 2-1/4 inches in overall length by 21/32 inches in diameter.

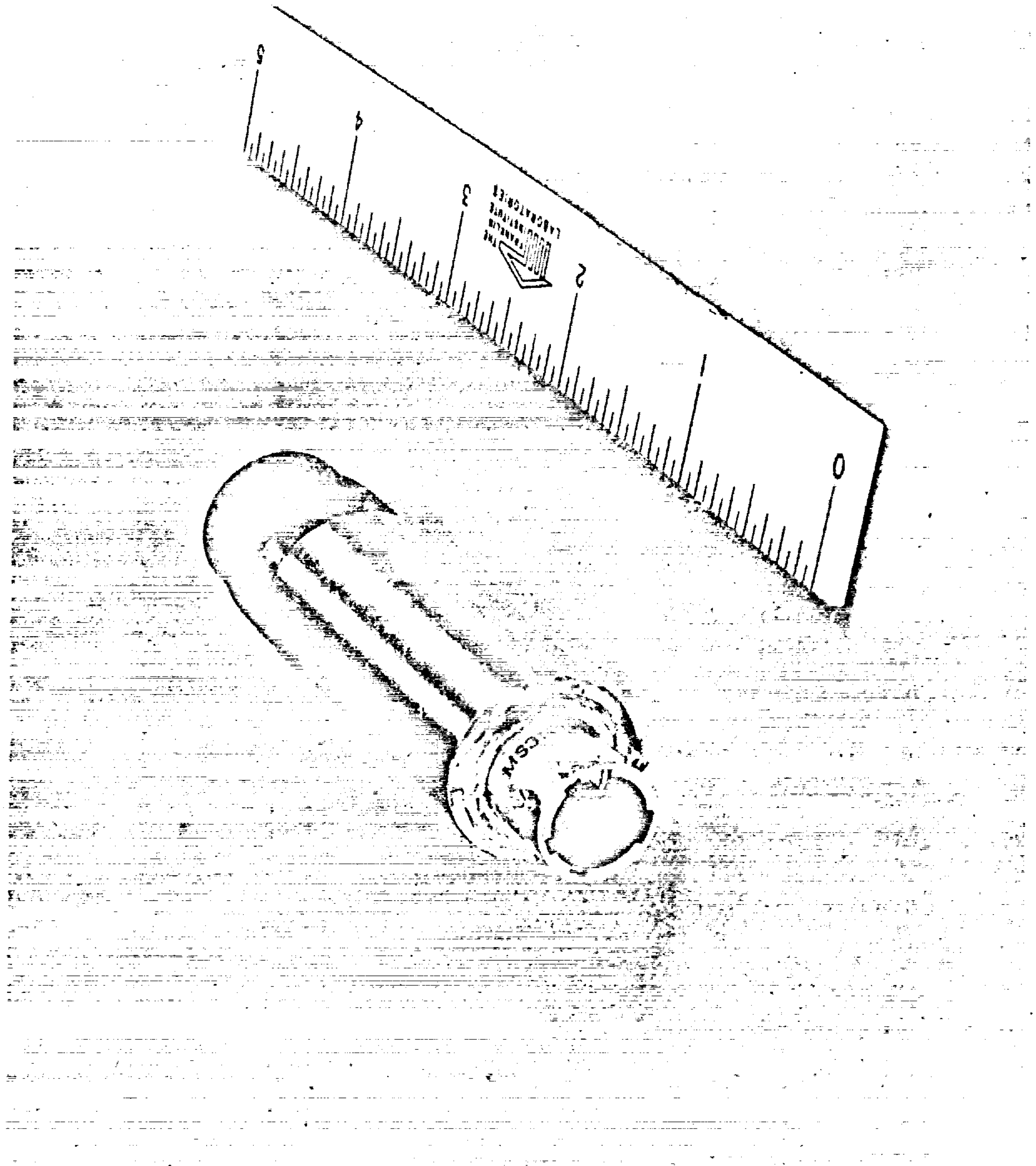


FIG. 2-1. FIRL 4-PIN HYBRID FILTER

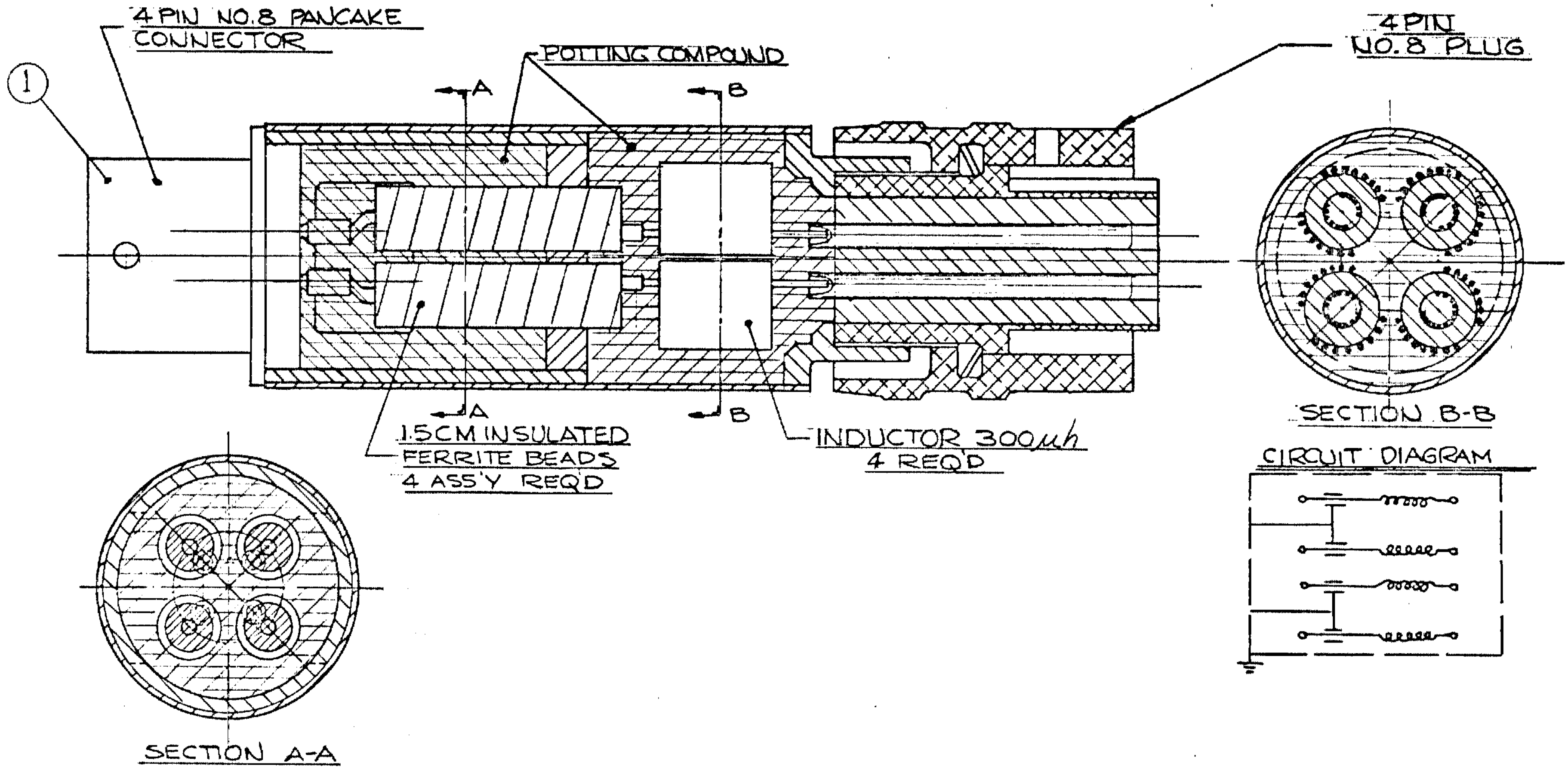


FIG. 2-2. ASSEMBLY DRAWING OF 4-PIN HYBRID FILTER

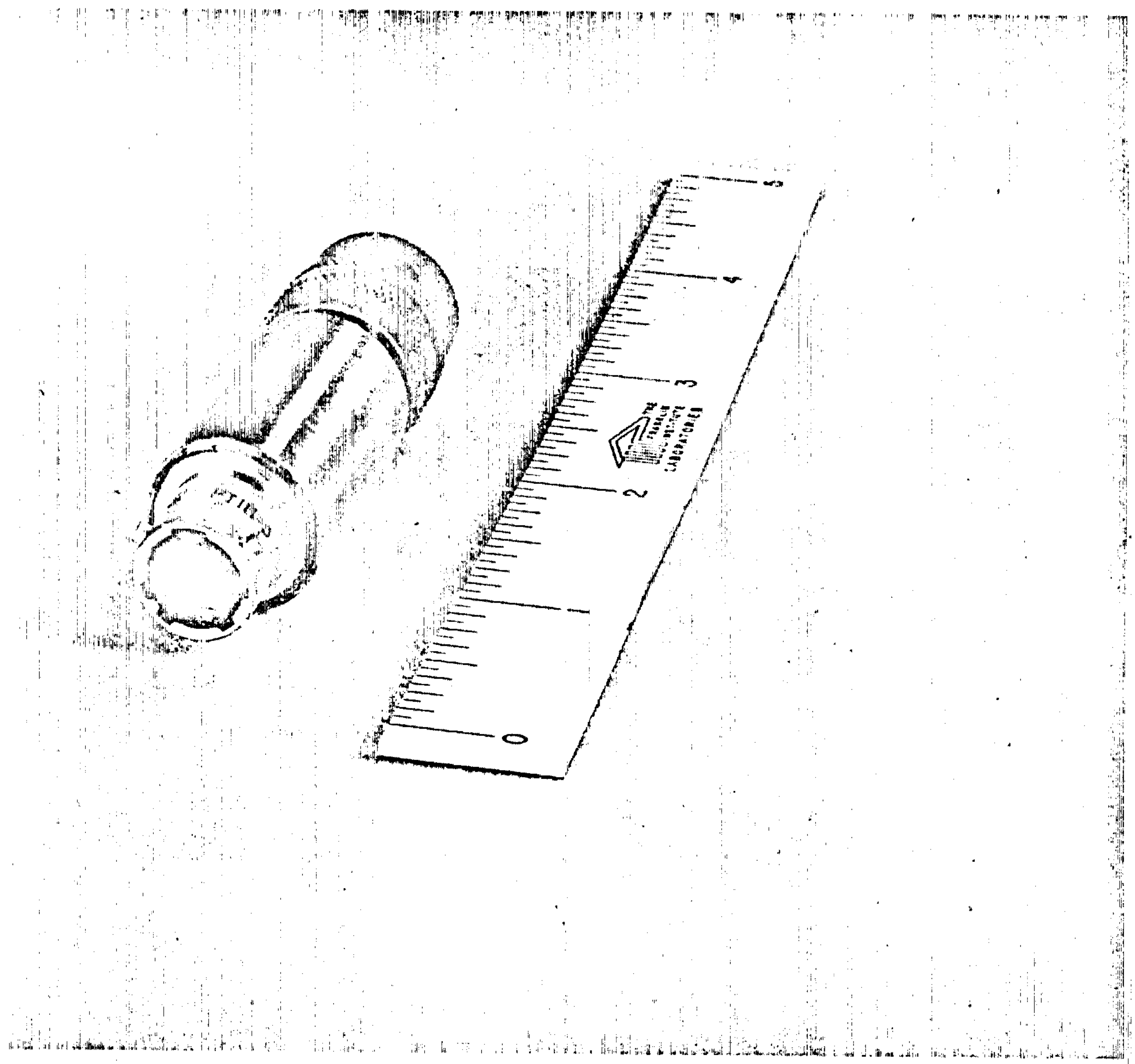


FIG. 2-3. FIRL 2-PIN HYBRID FILTER

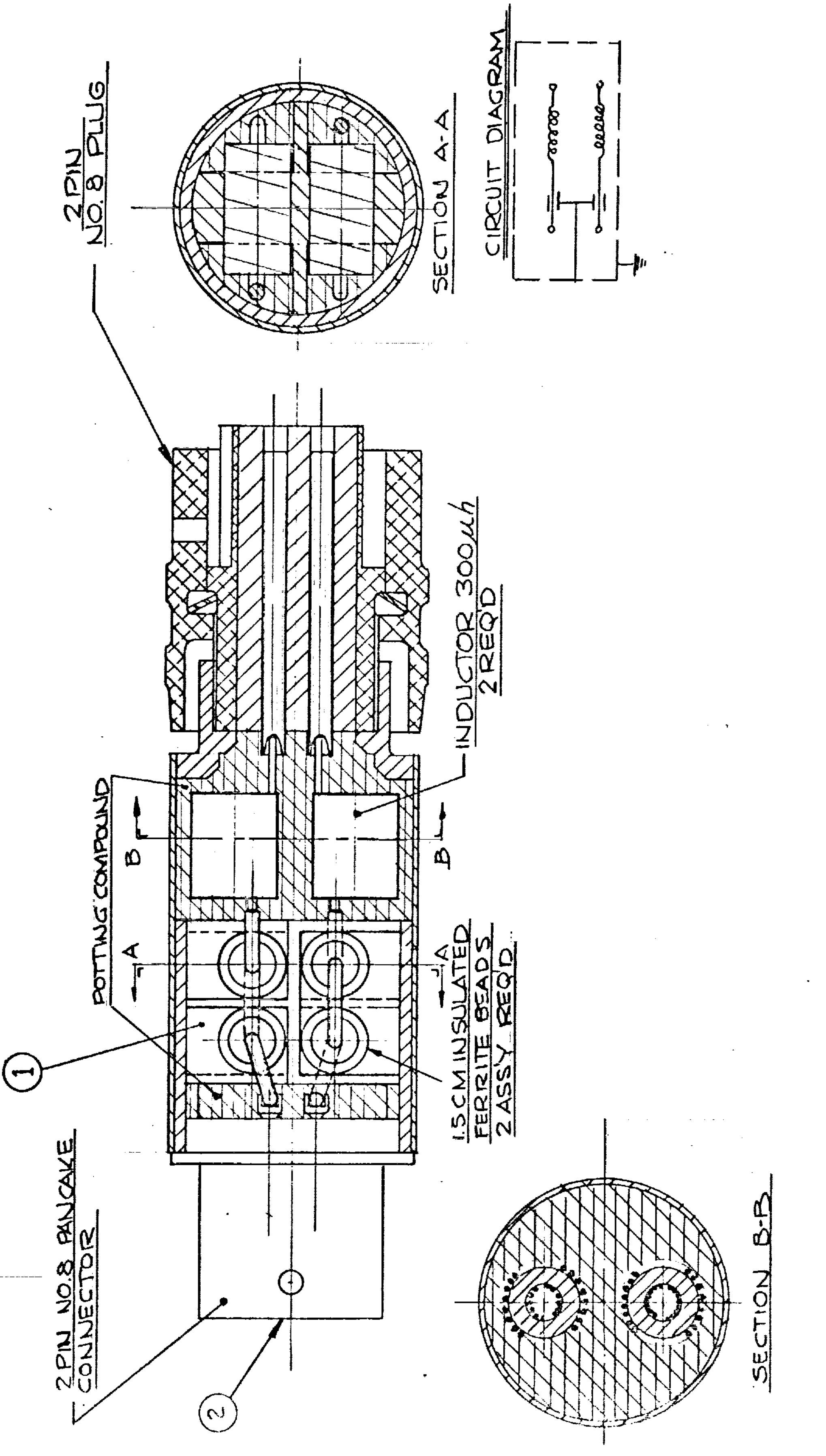


FIG.2-4. ASSEMBLY DRAWING OF 2-PIN HYBRID FILTER

3. EVALUATION OF FILTERS

3.1 Terminated Power Loss Measurements

The systems used to determine the terminated power loss for the hybrid filters are shown schematically in Figures 3-1 and 3-2.

Figure 3-1 is the system used to measure TPL in the range of 100 kHz to 3 MHz and Figure 3-2 is used to measure the TPL at 10 MHz and up.

Figures 3-3 through 3-14 are plots of the measurements taken for the twelve filters. In each measurement, a one ohm termination was used to simulate the Apollo Standard Initiator bridgewire resistance.

3.1.1 Discussion of Graphs

Filters 9101, 9102, 9103, 9107, 9108, 9109 are filters of the two pin type (See Figure 2-4) and filters 9104, 9105, 9106, 9110, 911, 9112, are of the four pin type (See Figure 2-2). If the graph in Figure 3-3 for filter 9101 is examined it will be noted that under the serial number are the words "average loss, Sections A-B" which is interpreted as follows: The connector has two pins, A and B. Each of these connects to a complete filter, therefore we measure each one separately. Results of the evaluation were that the two filters were nearly identical, therefore, we averaged the two and plotted these values on the graphs. This was done for each filter with the exception of filter 9104, Figure 3-6. In this case, the filter being a four pin type, we averaged the values for pins A, B and D but the power loss for pin C was plotted separately. This was done so as not to influence the data for the other pins, because the values for pin C were somewhat lower. This ferrite and coil assembly in pin C evidently has a flaw in its construction which is preventing it from attenuating as well as the others. It must be realized that the ferrites are off the shelf items and are sold with a tolerance of ± 20% of their published values of

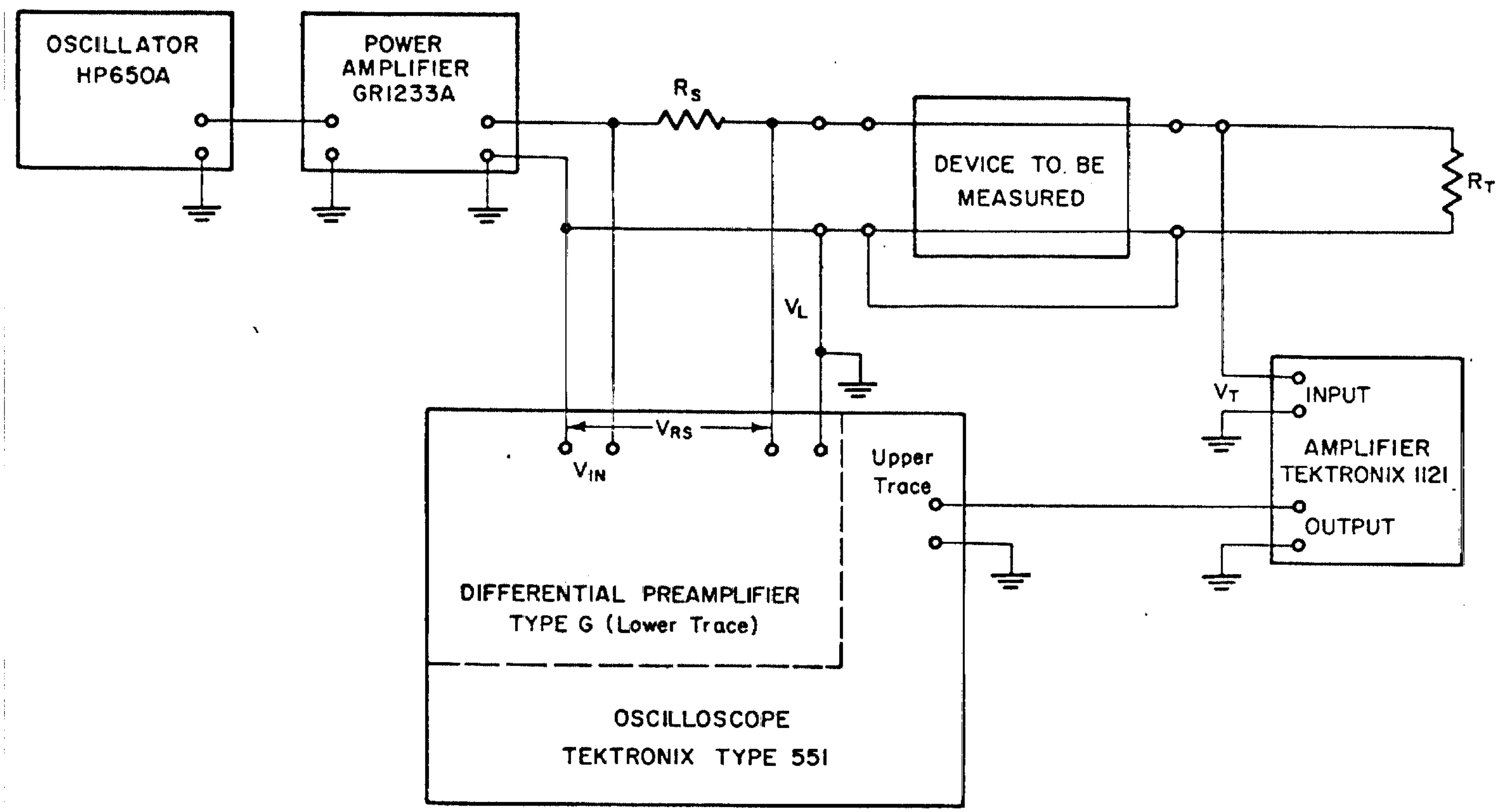


FIG. 3-1. TPL MEASUREMENT SYSTEM (100 kHz TO 3 MHz)

permeability and loss tangent. Combinations of inaccuracies in assembly technique would also help to explain the difference. It should be noted, however, that even with these possible variations the filters are very reproducible in terms of their electrical parameters.

Readings at 10 MHz and above were listed on the graph as 60db, terminated power loss. For the most part, the measurements taken at these frequences were above 60 db but because of equipment limitations we were not able to determine them exactly. We therefore plotted them as 60db across the band.

3.1.2 Potting Problem

It is also apparent by study of the graphs that filters 9104, 9105, 9106 and 9101, 9102 and 9103 exhibit loss capabilities approximately 10 db lower than the others at frequencies of 100 kHz to 10 MHz.

After we built these six filters, the terminated power loss was determined and found to be lower. Naturally, when this discrepancy became known we sought an explanation since all methods of measurement, materials, and techniques were substantially the same. Upon careful analysis and some experimentation it was determined that the epoxy potting compound that we had chosen for its heat dissipating capabilities was the only factor in the assembly that conceivably might be causing the change. We therefore discontinued the use of epoxy type potting compounds and settled on a silastic compound which was used on the filters 9110, 9111, 9112, 9107, 9108, 9109.

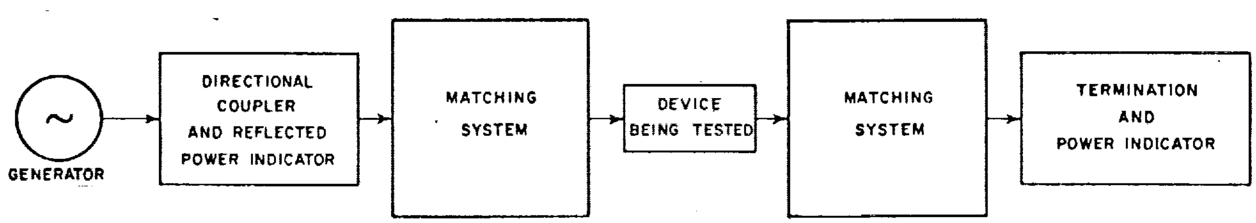


FIG. 3-2. DIAGRAM OF TPL MEASUREMENT SYSTEM USING MATCHING NETWORKS (10MHz AND UP)

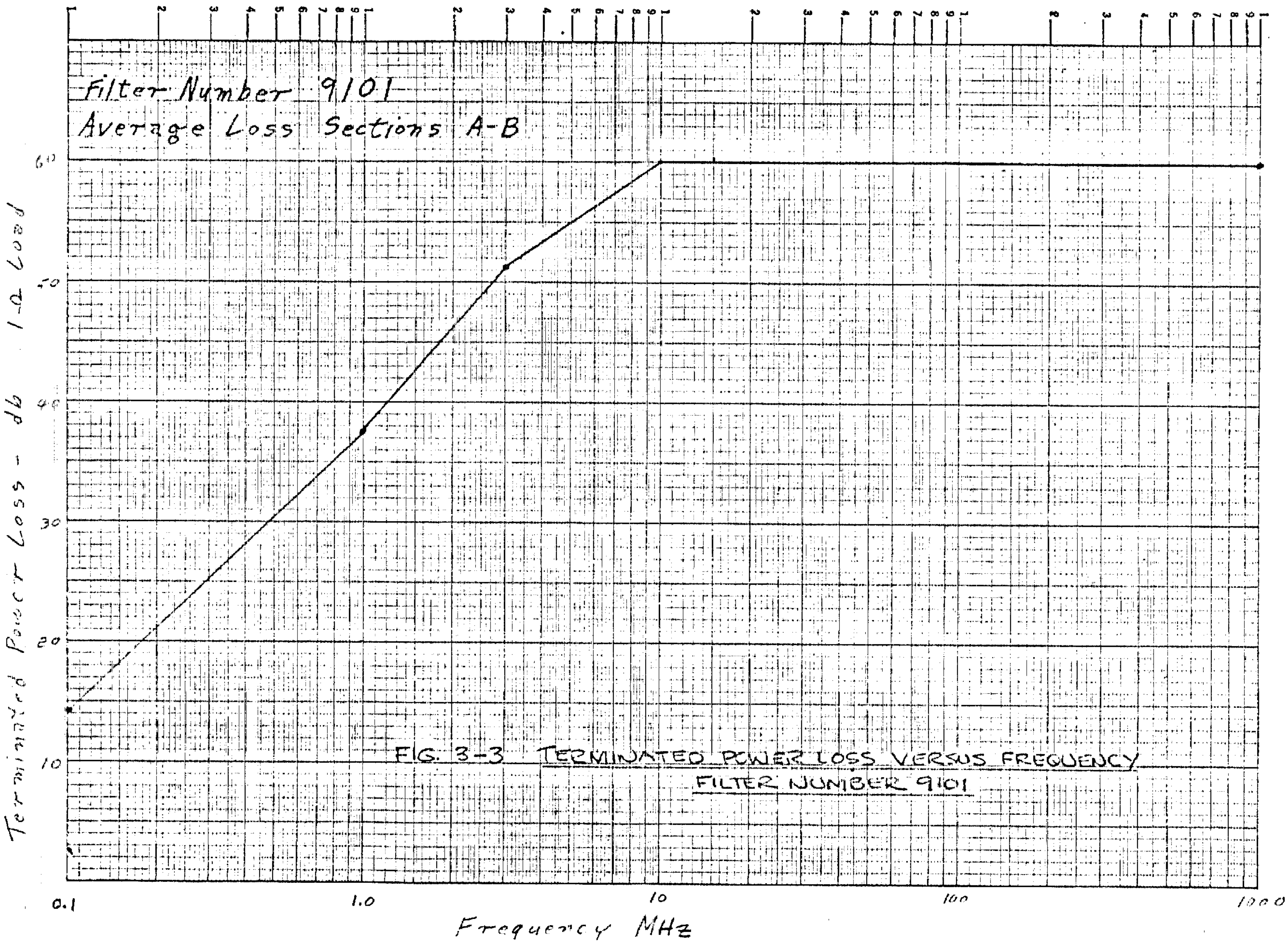


FIG. 3-3 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9101

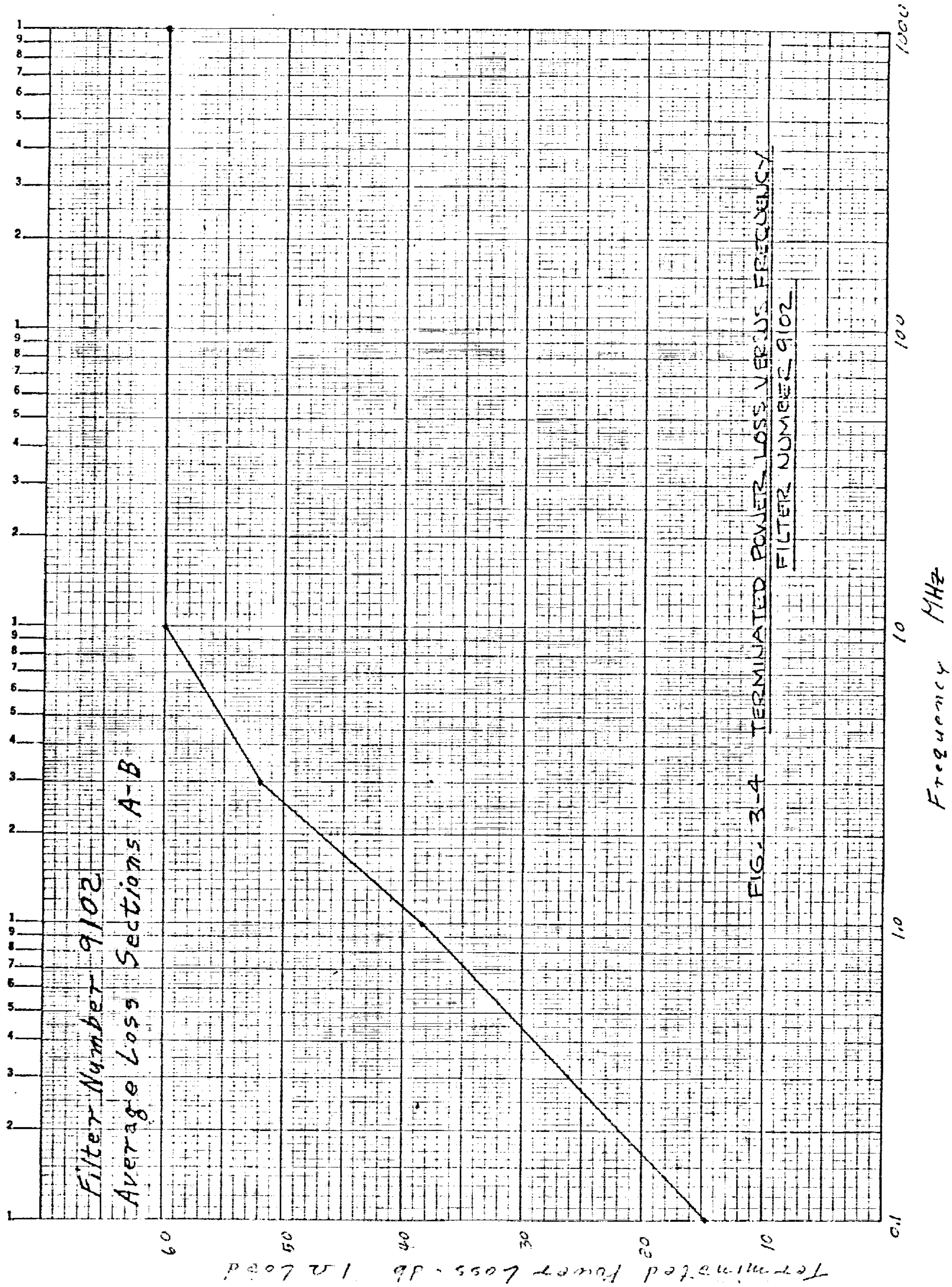
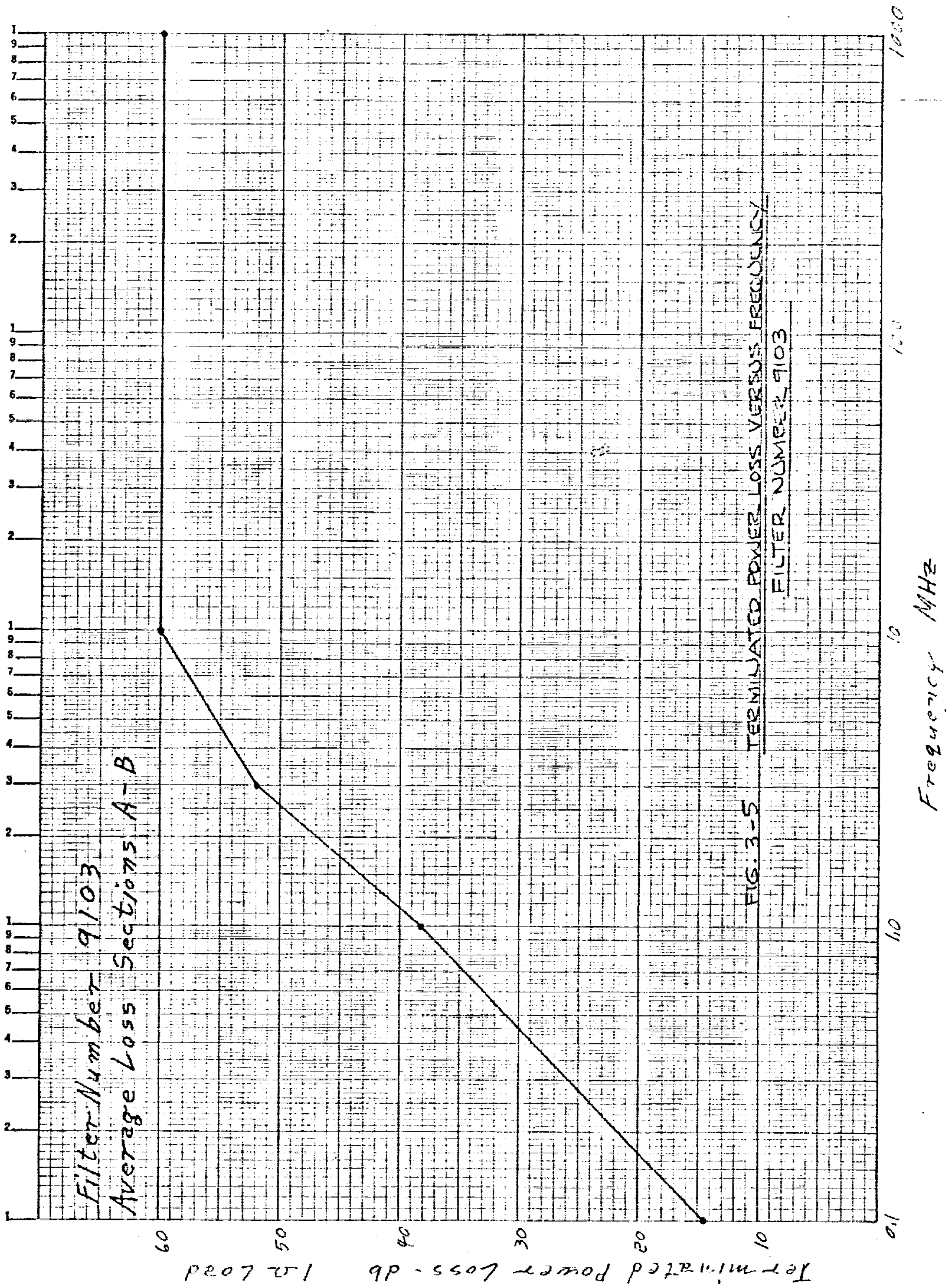


FIG. 3-4 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9102


Filter Number 9103
Average Loss Sections A-B
FIG. 3-5 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9103
Frequency MHz
Terminated power loss - db 1Ω Load
60
50
40
30
20
10

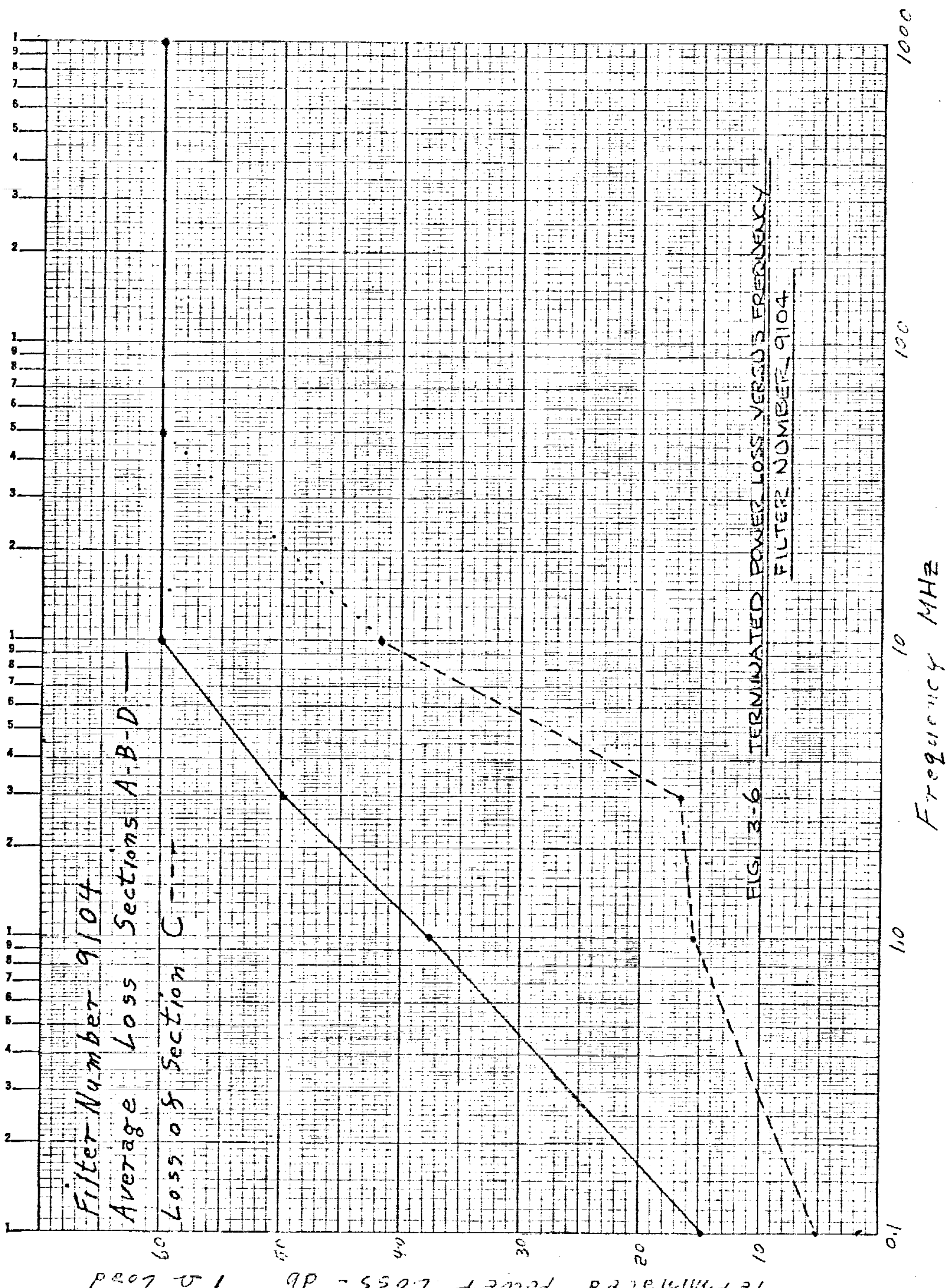


FIG. 3-6 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9104

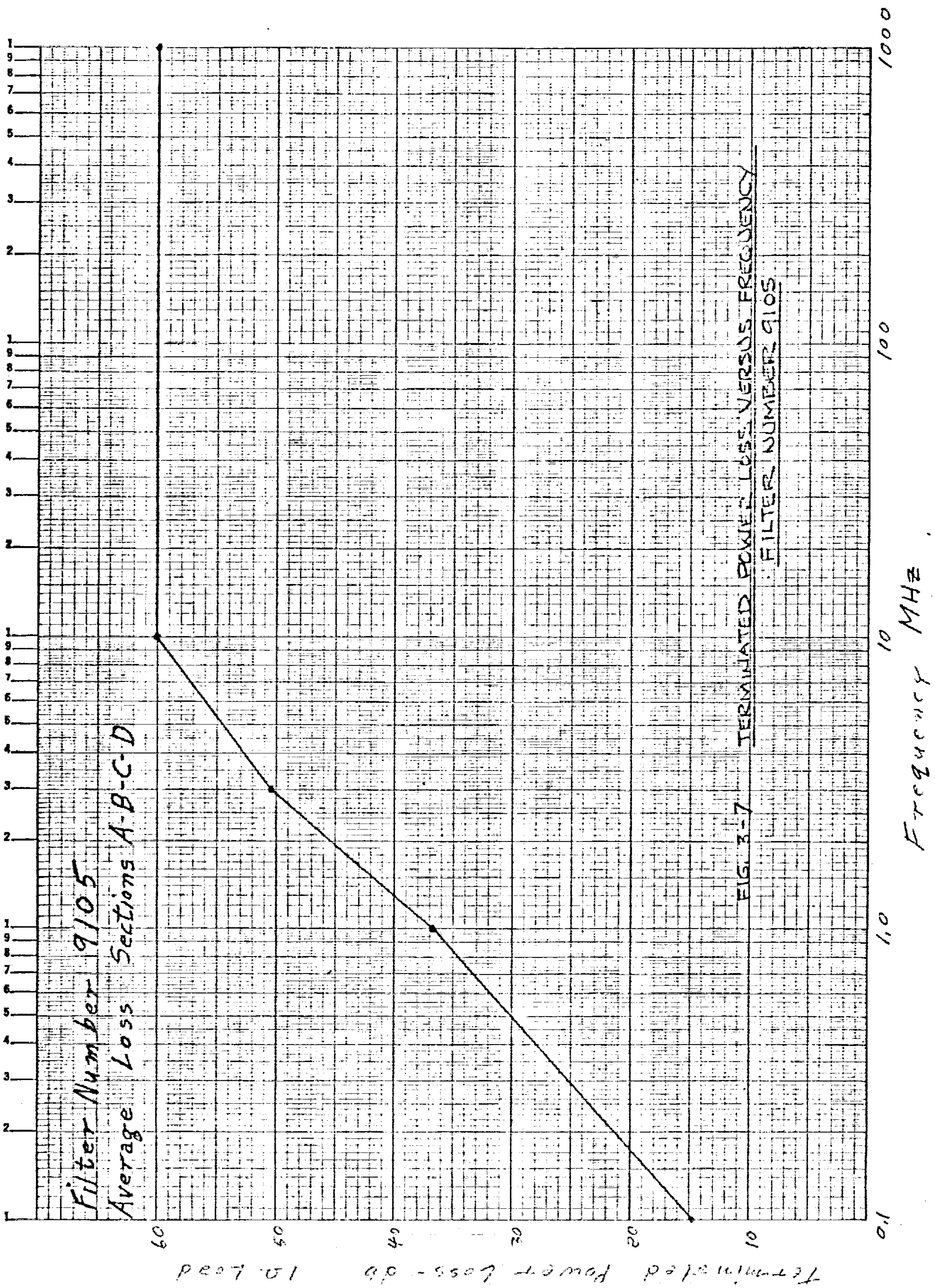


FIG. 3-7 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9105

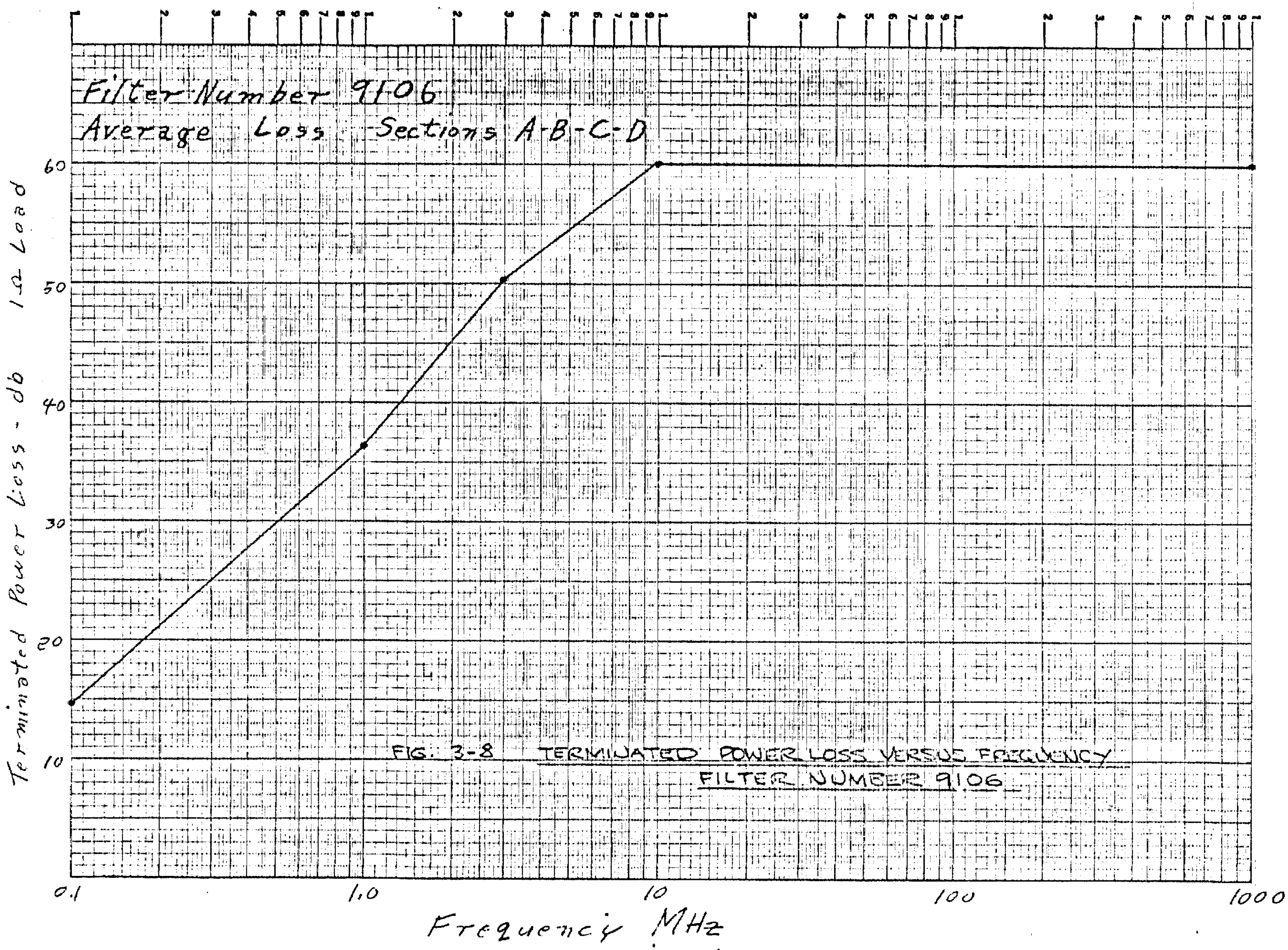
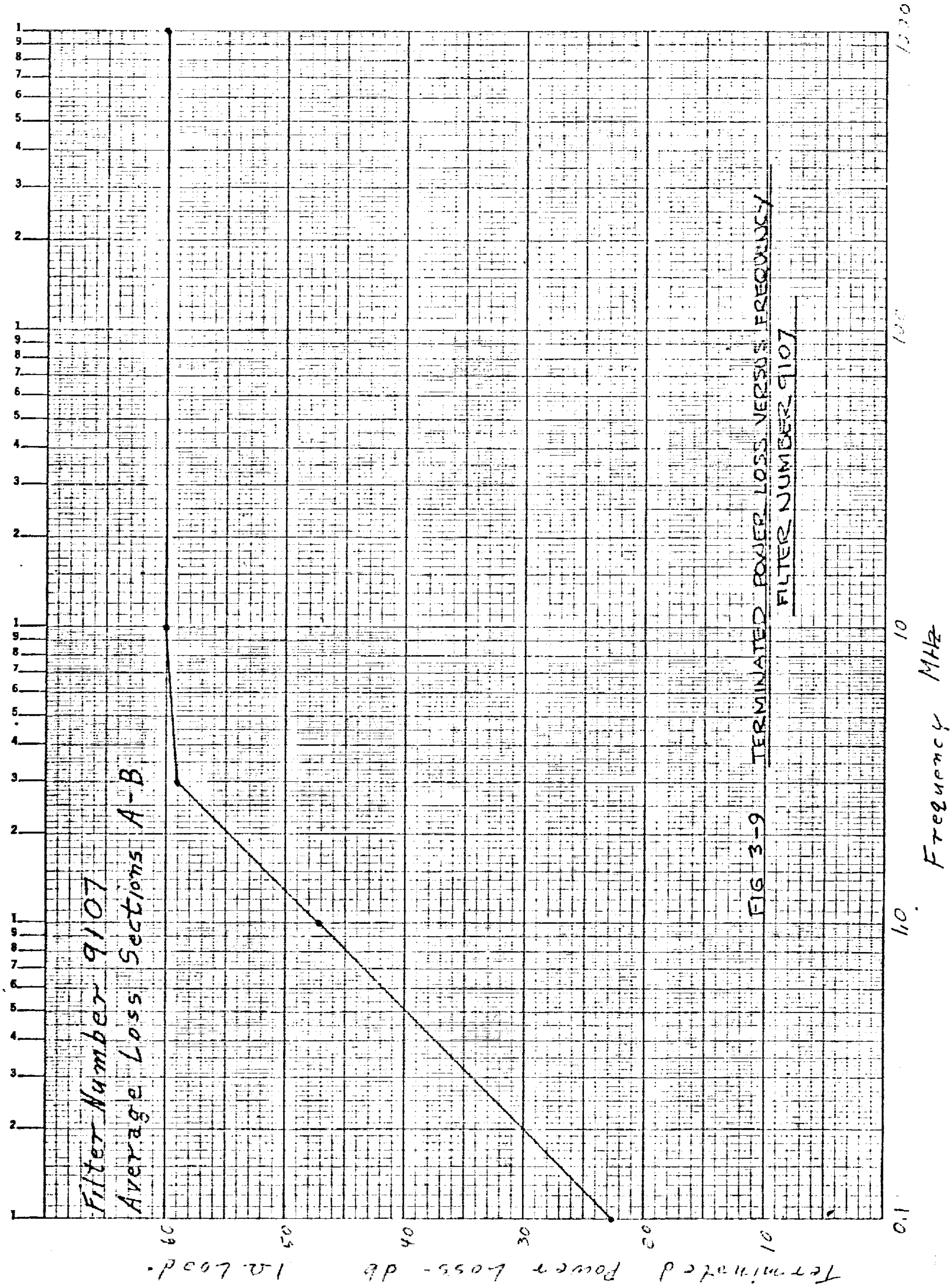


FIG. 3-8 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9106


Filter Number 9107
Average Loss Sections A-B
FIG 3-9 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9107
0.1
1.0
10
100
1000
Frequency MHz
60
50
40
30
20
10
Terminated Power Loss - db 1Ω Load.

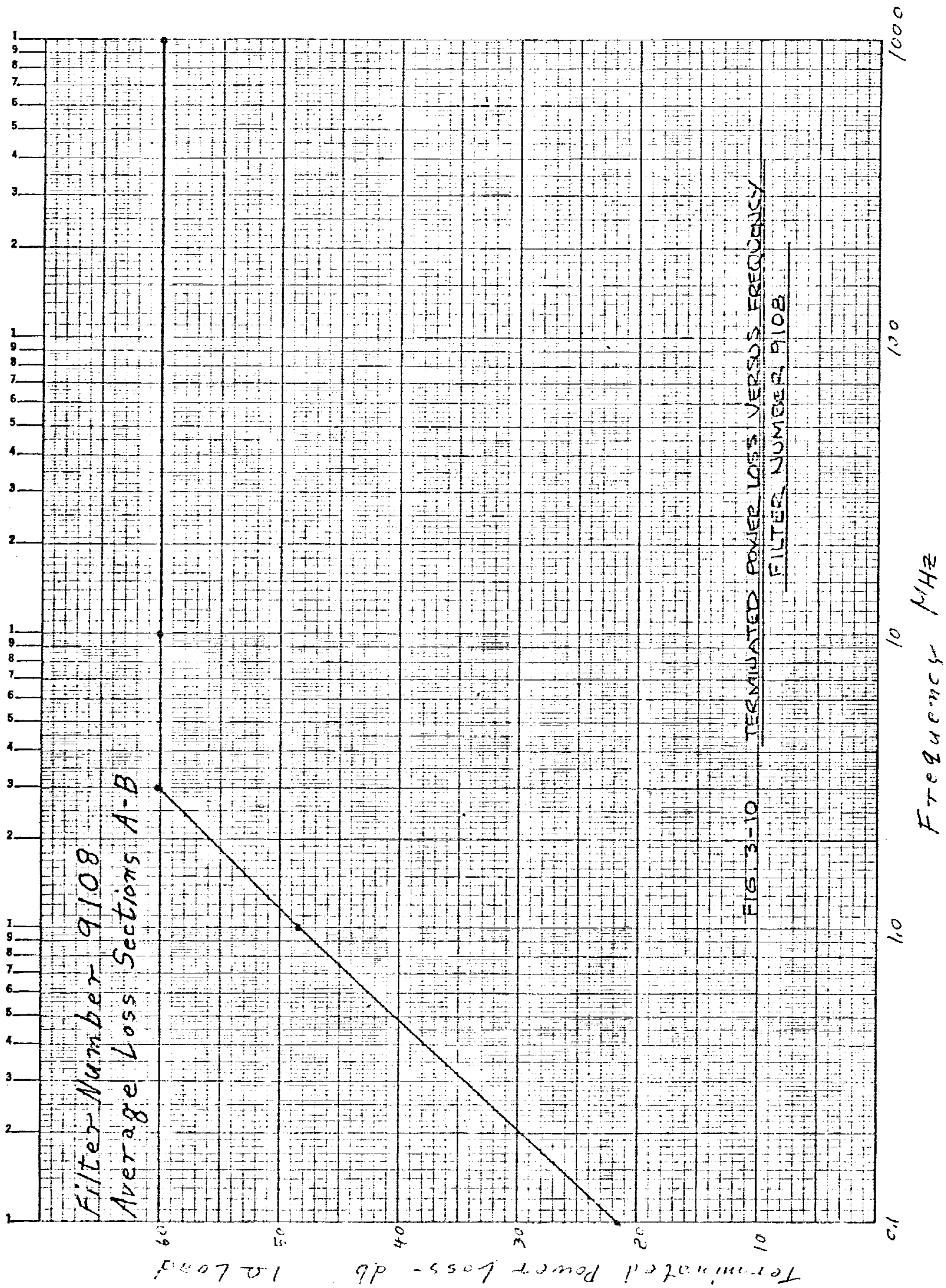


FIG. 3-10 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9108

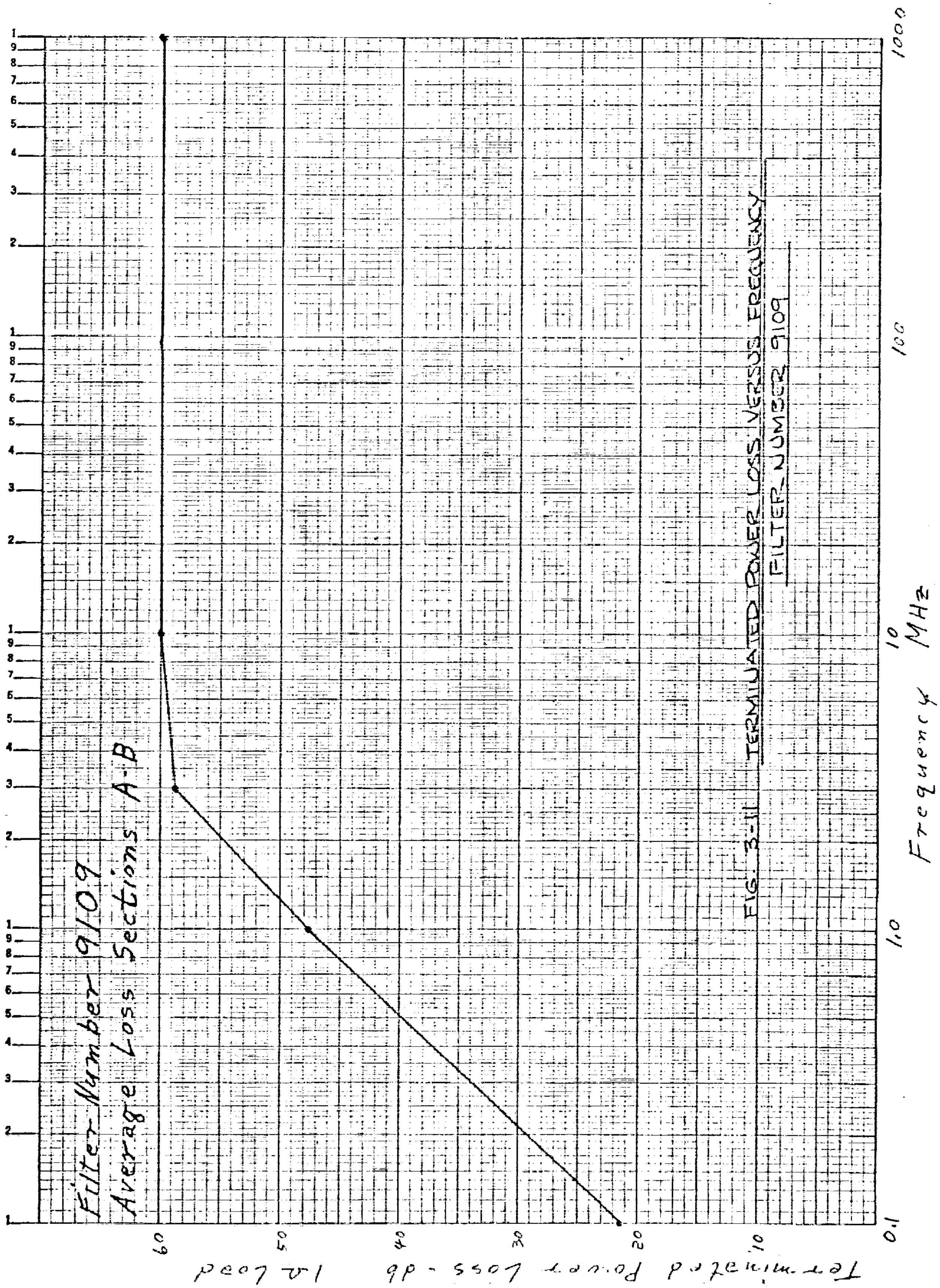
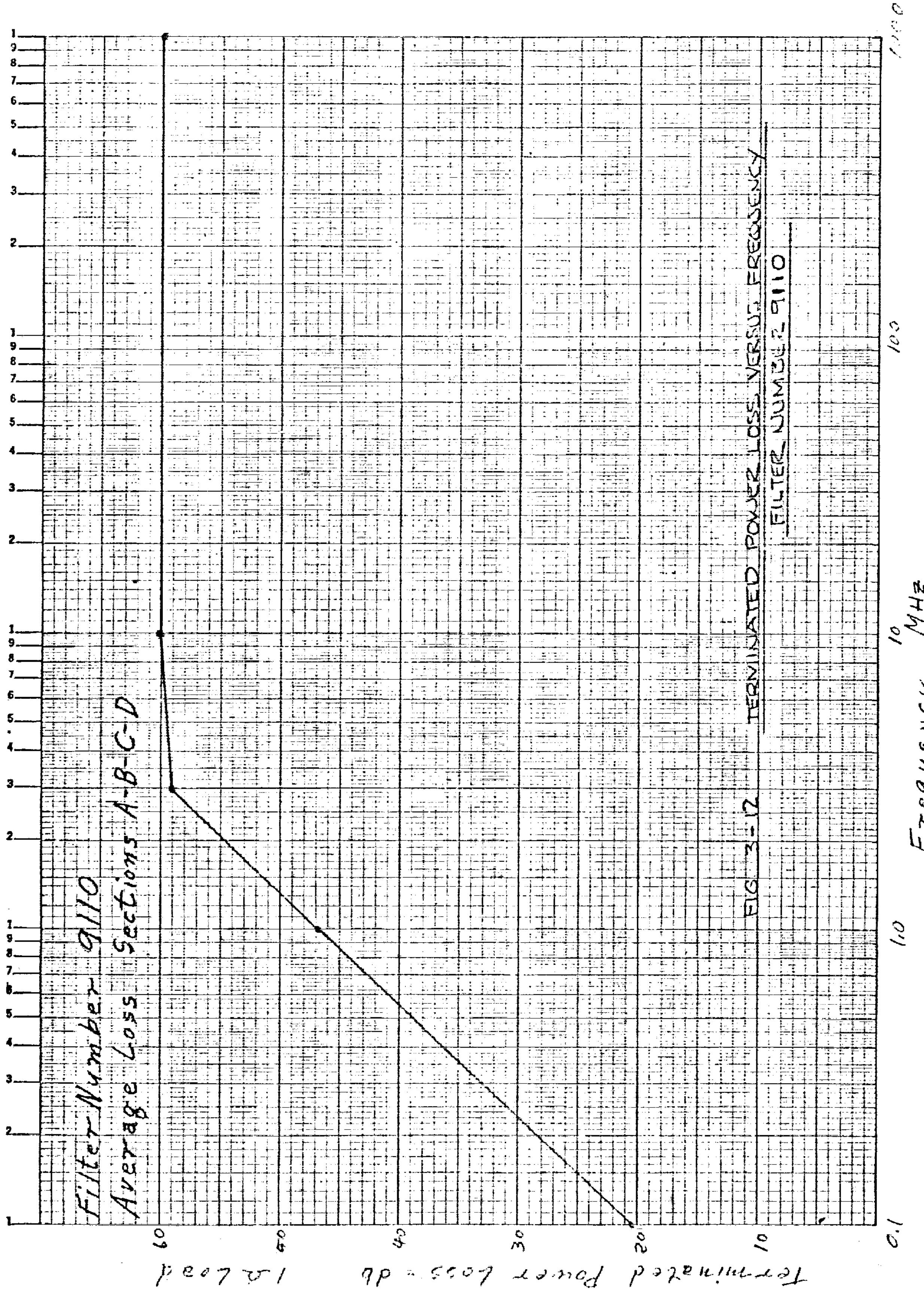


FIG. 3-11 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9109



Filter Number 9110
Average Loss Sections A-B-C-D
FIG 3-12 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9110
Frequency MHz
0.1
1.0
10
100
1000
Terminated Power Loss - db 1Ω Load
60
50
40
30
20
10

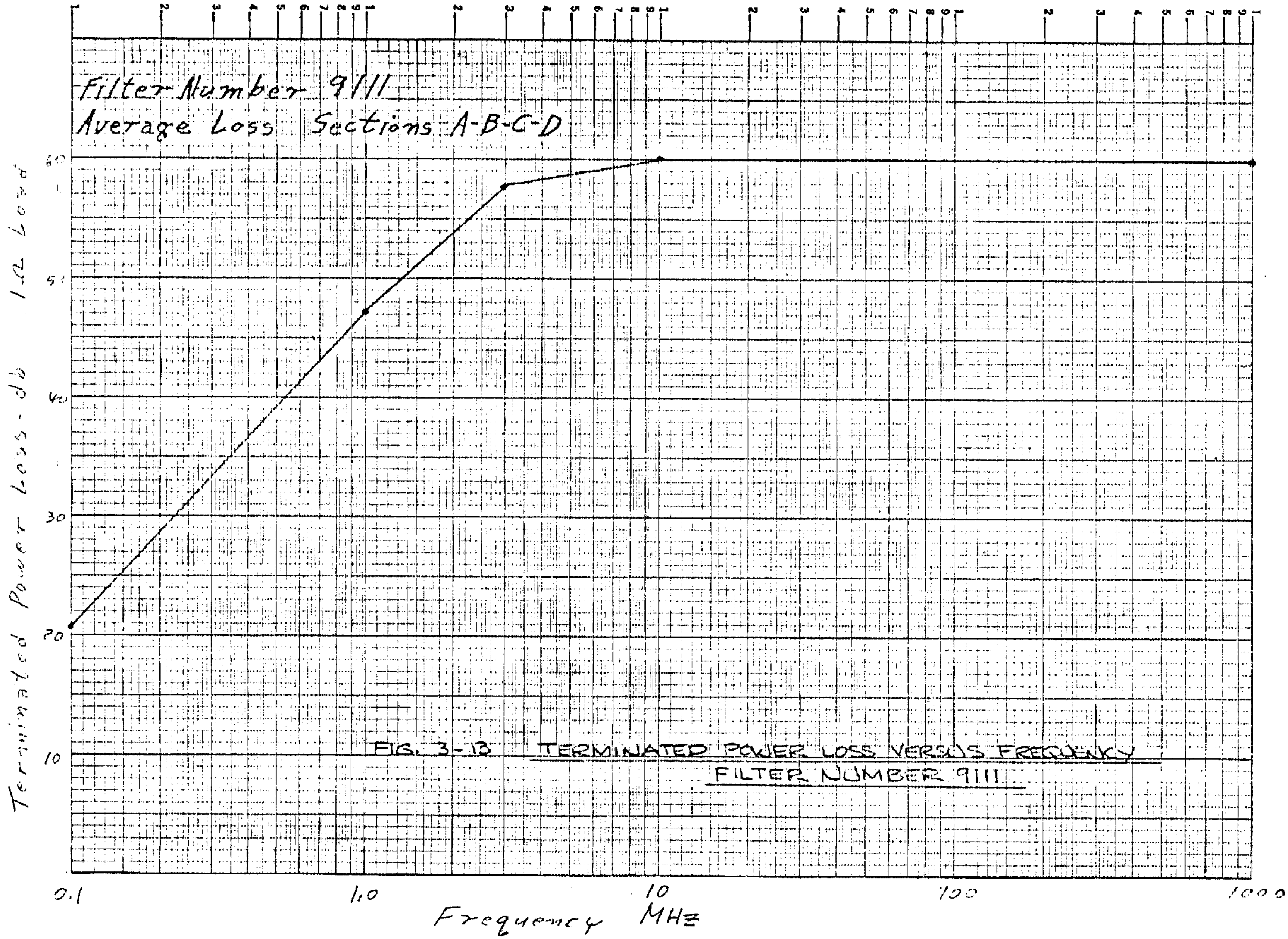


FIG. 3-13 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9111

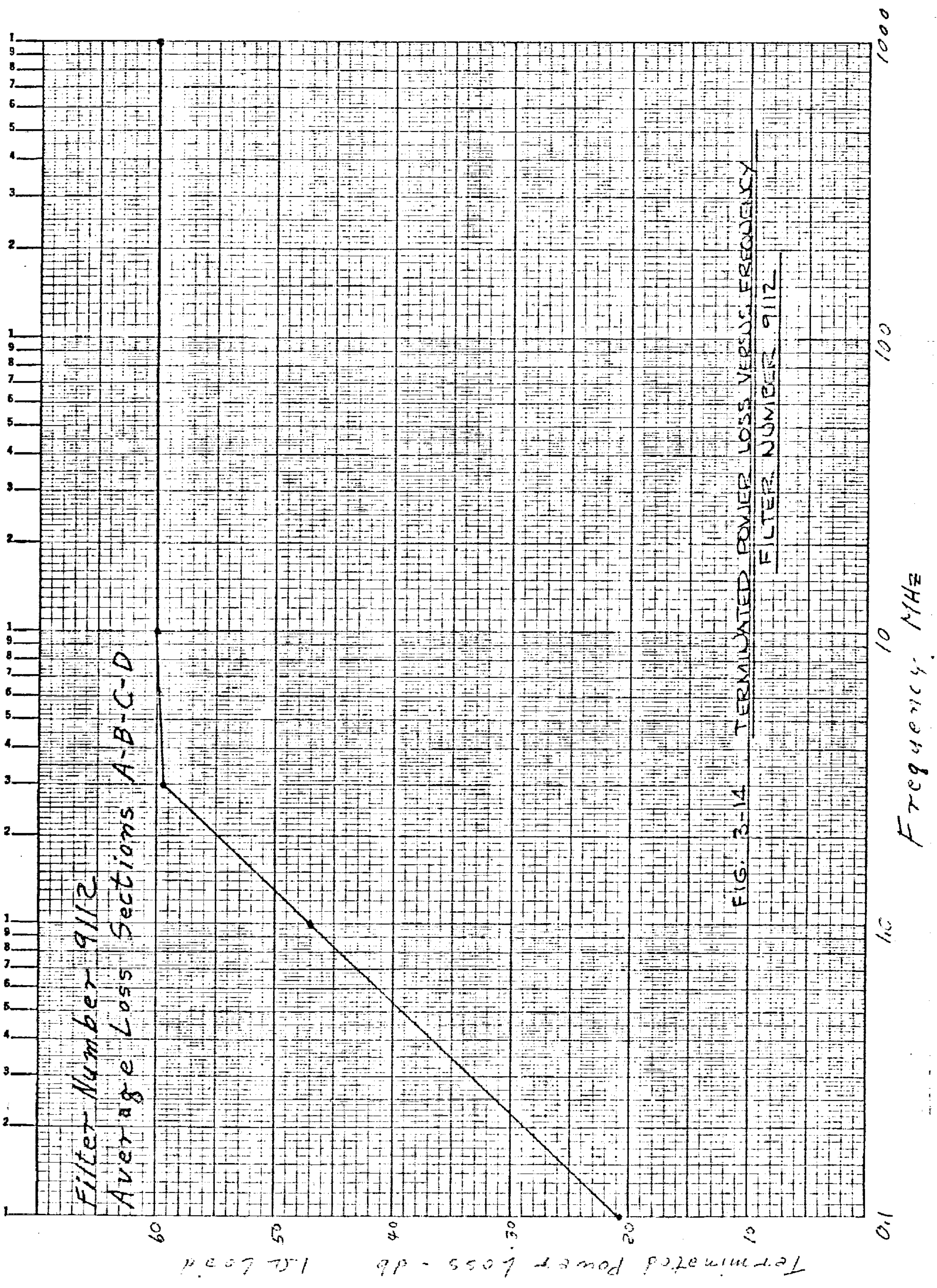


FIG. 3-14 TERMINATED POWER LOSS VERSUS FREQUENCY
FILTER NUMBER 9112

These filters exhibited attenuation capabilities which equalled or exceeded the values that had been originally indicated as possible in the original proposal. Incidentally, the original prototype for which the data had been taken and presented had not been potted with an epoxy compound and thus this problem had not been encountered.

3.2 Electrical Properties

Other electrical properties that were determined after these filters were constructed are listed in Table 3-1.

TABLE 3-1 ELECTRICAL PROPERTIES

dc series resistance	0.15 ohms
shunt resistance	10^7 ohms
voltage breakdown	500 volts dc min
power handling capacity	10 watts minimum
effect on capacitor discharge pulse	negligible

In regard to the power handling capacity, we have not used greater than 10 watts since we did not want to take a chance on damaging the devices, therefore we have not determined the upper limit of this parameter.

Another attribute of these filters that was investigated was that of RF leakage at frequencies up to 2000 MHz. There was no appreciable evidence of leakage observed.

4. CONCLUSIONS

Twelve RF attenuating filters have been designed, constructed and tested for use in circuits containing Apollo Standard Initiators. Six of these are of the type to be used with double bridge wire or four lead devices; six are of the type to be used with a single bridge wire or two lead version of the ASI. In addition three of each type had their inductors potted in epoxy and three of each type were potted in silastic. It was determined that the epoxy slightly degraded the low frequency (below 10 MHz) performance of the filters.

A study of the six curves for each type of potting indicates that the reproducibility of the filters is excellent; i.e., the curves of the filters potted with epoxy are almost identical and those of the filters potted with silastic are almost identical.

In summary, then, we have RF filters which show excellent terminated power loss when used with the ASI down to 100 kHz and adequate terminated power loss to even lower frequencies which will dissipate at least ten watts of power and which will have minimal effects on normal firing pulses. Present construction is somewhat demanding, but produces highly reproducible characteristics. Evidence indicates that some of the construction features could be eventually relaxed, but additional study is required to assure this. If this were possible, less expensive filters would be possible. At present, however, we must hold to the current contruction requirements.